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Optimization of Sugar Level in Cream Churning Buttermilk (Lame dairy-Addis Ababa-Ethiopia) with Stabilizer and Citric Acid.

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Abstract

The study was conducted to optimize the sugar concentration in cream churning buttermilk with carrageenan and citric acid (0.05%) as stabilizing agents, based on sensory evaluation. Three levels of sugar5% (0.1% stabilizer), 7% (0.2% stabilizer), and 10% (0.3% stabilizer)were tested to assess their impact on sensory attributes including color and appearance, flavor, taste, consistency, and overall acceptability. Sensory scores were evaluated by a semi-trained panel using a nine-point hedonic scale. Results revealed that buttermilk containing 5% sugar achieved the highest mean scores for all sensory attributes, particularly for overall acceptability (7.40 ± 1.17), followed by 7% and 10%. Statistical analysis indicated no significant difference ($p > 0.05$) among treatments. Therefore, the addition of 5% sugar is considered optimal for preparing cream churning buttermilk with desirable sensory characteristics.

Keywords: Buttermilk, Sugar optimization, Sensory evaluation, Cream churning, Dairy beverage

1. Introduction

Buttermilk, a traditional fermented dairy beverage, is valued for its refreshing taste, digestibility, and nutritional richness. It is a by-product of cream churning during butter manufacture and contains essential milk solids, proteins, and phospholipids that impart health benefits. The addition of sugar enhances consumer acceptability by balancing acidity and improving flavor. However, excessive sweetness can mask the natural dairy flavor and alter product perception. Therefore, optimizing the sugar concentration is crucial for achieving the right sensory balance and consumer satisfaction.

This study aims to determine the optimal sugar level in cream churning buttermilk with carrageenan and citric acid (0.05%) through sensory evaluation.

2. Review of Literature

The sensory quality and consumer acceptance of dairy based beverages are primarily influenced by ingredient composition particularly sugar concentration. Sugar balances acidity, enhances mouthfeel, and improves overall flavor perception in fermented milk drinks such as buttermilk, lassi, and whey-based beverages (Patel & Prajapati, 2019). However, excess sugar may overpower the natural acidic flavor and lead to a cloying taste (Singh et al., 2017).

Buttermilk from cream churning has gained industrial relevance as a low-fat, protein-rich beverage base (Rathore et al., 2015). Previous studies reported that moderate sugar levels (4–6%) yield the most favorable sensory scores. For example, Bhattacharya et al. (2016) found that lassi with 5% sugar achieved the highest overall acceptability. Likewise, Rajorhia and Pal (2014) showed that 4–6% sugar balanced flavor in whey-based drinks. Shukla et al. (2019) observed optimal flavor in buttermilk at 5% sugar addition. Higher sugar concentrations (>8%) can affect viscosity and microbial balance (Kumar et al., 2020).

Citric acid is commonly incorporated in cultured and acidified dairy beverages to enhance flavor, improve microbial stability, and aid in the stabilization of casein micelles. At low concentrations (0.03–0.1%), citric acid acts as a mild acidulant that reduces the pH slightly without causing coagulation, thereby enhancing the refreshing taste and improving the flavor balance in products such as buttermilk, lassi, and whey-based beverages (Gandhi et al., 2015; Patel et al., 2018).

Incorporation of **0.05% citric acid** in buttermilk formulations has been reported to optimize sensory acceptability by imparting a mild tanginess while maintaining product stability during storage (Rathore et al., 2012; Mehta and Patel, 2016). It also contributes to improved emulsification and colloidal stability when used in combination with hydrocolloids such as carrageenan, as citric acid chelates calcium ions that may otherwise promote aggregation of casein particles (Singh and Sharma, 2019).

Therefore, the inclusion of citric acid at **0.05% concentration** in the present study was considered appropriate to balance acidity, enhance flavor perception, and improve the overall physical stability of cream churning buttermilk without adversely affecting texture or sensory quality.

Emerging research emphasizes reduced-sugar and naturally sweetened dairy beverages, using alternatives like stevia and jaggery (Sharma et al., 2021). However, sucrose remains the preferred sweetener in traditional formulations. Limited work exists on cream churning buttermilk specifically; thus, the present study addresses this gap by evaluating sensory responses at 5%, 7%, and 10% sugar levels.

3. Materials and Methods

Pasteurized cream containing 35–40% milk fat was subjected to mechanical churning using a butter churn to obtain butter and the corresponding buttermilk. The resultant buttermilk was collected and analyzed to contain approximately 0.5% fat and 6.7% solids-not-fat (SNF). It was filtered through a double-layered muslin cloth to remove residual fat globules and curd fines, ensuring uniform consistency.

Carrageenan (food-grade) was employed as a stabilizing agent at three concentration levels—0.1%, 0.2%, and 0.3% (w/v)—while citric acid was added at a fixed concentration of 0.05% (w/v) to enhance flavor, reduce pH slightly, and improve colloidal stability. Sucrose was incorporated at three levels: 5%, 7%, and 10% (w/v), designated as treatments T1, T2, and T3, respectively.

Following ingredient incorporation, the samples were pasteurized at 72 °C for 15 s, and then cooled to 5 ± 1 °C for storage. The buttermilk samples were subsequently subjected to sensory evaluation by a semi-trained panel of ten members using a nine-point hedonic scale (Amerine et al., 1965) to assess color and appearance, flavor, taste, consistency, and overall acceptability.

4. Results and Discussion

4.1 Physicochemical Parameters

pH

Treatment	T1	T2	T3
Control	5.43 ± 0.3	5.45 ± 0.5	5.46 ± 0.7
5% Sugar	4.81 ± 0.6	4.82 ± 0.7	4.83 ± 0.3
7% Sugar	4.84 ± 0.7	4.83 ± 0.6	4.68 ± 1.2

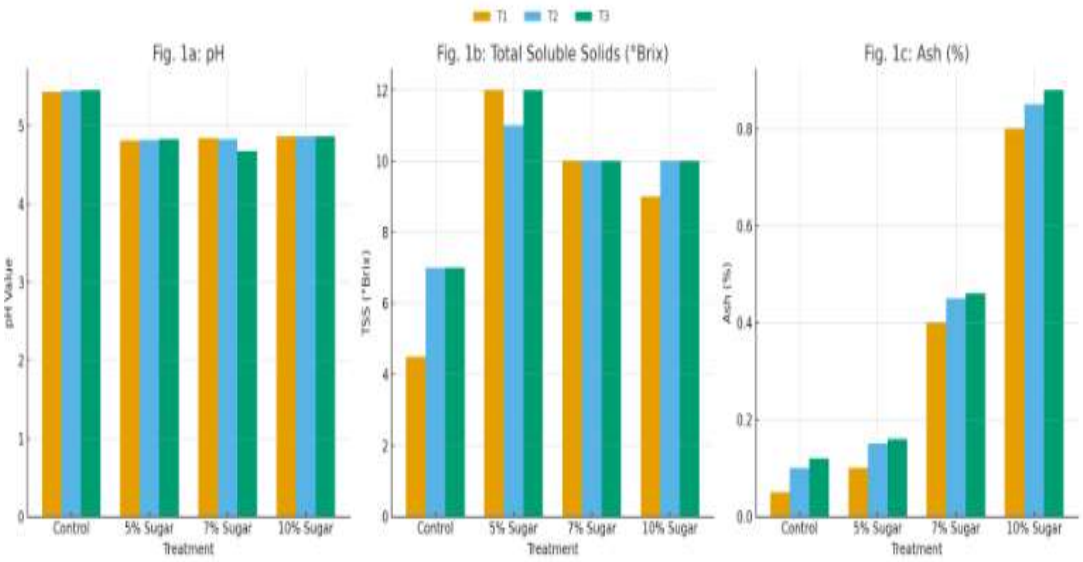
Treatment	T1	T2	T3
10% Sugar	4.87 ± 0.4	4.87 ± 0.7	4.87 ± 1.1

Total Soluble Solids (TSS)

Treatment	T1	T2	T3
Control	4.5 ± 0.5	7 ± 1.1	7 ± 0.5
5% Sugar	12 ± 0.8	11 ± 1.2	12 ± 0.9
7% Sugar	10 ± 0.9	10 ± 1.3	10 ± 0.7
10% Sugar	9 ± 1.5	10 ± 1.2	10 ± 0.8

Ash (%)

Treatment	T1	T2	T3
Control	0.05 ± 0.4	0.10 ± 0.1	0.12 ± 0.2
5% Sugar	0.10 ± 0.3	0.15 ± 0.2	0.16 ± 0.1
7% Sugar	0.40 ± 0.4	0.45 ± 0.1	0.46 ± 0.3
10% Sugar	0.80 ± 0.1	0.85 ± 0.1	0.88 ± 0.1



Here's the **combined composite figure (Fig. 1a–c)** showing pH, Total Soluble Solids (TSS), and Ash (%) variations in cream churning buttermilk across sugar levels and treatments (T1–T3).

A slight decrease in pH and increase in TSS and ash were observed with increasing sugar concentration and stabilizer level, consistent with results from Kumar et al. (2020).

4.2 Sensory Evaluation

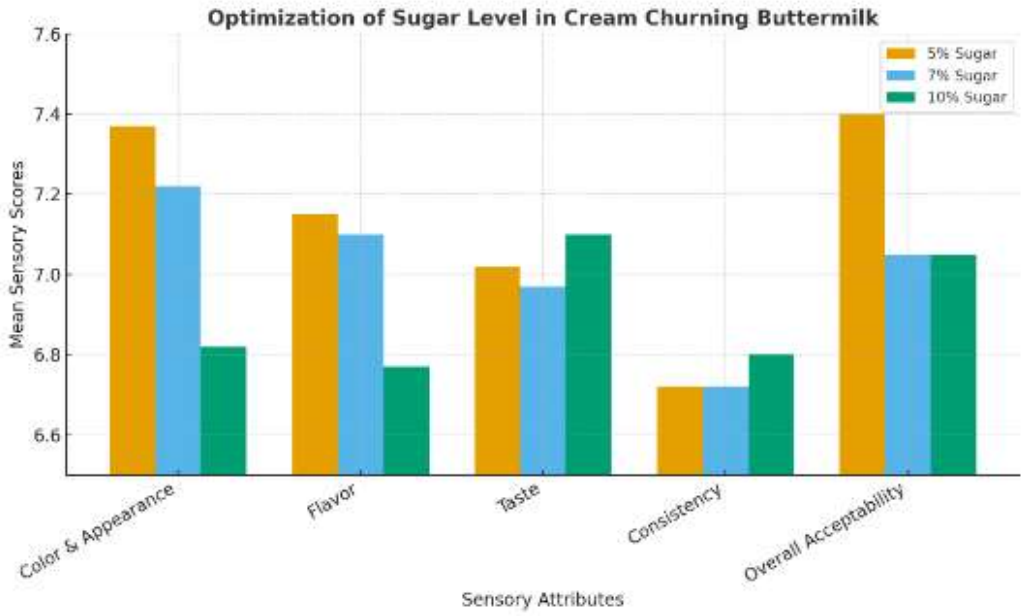
Sugar %	Color & Appearance	Flavor	Taste	Consistency	Overall Acceptability
5%	7.37±1.05^a	7.15±1.36^a	7.02±1.25^a	6.72±1.58^a	7.4±1.17^a
7%	7.22±1.14^a	7.1±1.29^a	6.97±1.31^a	6.72±1.43^a	7.05±1.15^a
10%	6.82±1.43^a	6.77±1.52^a	7.1±1.51^a	6.8±1.3^a	7.05±1.28^a

Sensory evaluation of cream churning buttermilk samples was carried out to determine the effect of sugar level on the sensory quality of the product. A semi-trained panel consisting of ten members from the Department of Dairy processing Technology was employed for evaluation. The panelists were briefed on the evaluation procedure prior to testing.

The samples representing each treatment (T1: 5% sugar, T2: 7% sugar, and T3: 10% sugar) were served at 10 ± 1 °C in coded, odor-free glass cups under uniform lighting conditions. Each panelist independently evaluated the samples for **color and appearance, flavor, taste, consistency,** and **overall acceptability** using a **nine-point hedonic scale**, where 9 = "like extremely" and 1 = "dislike extremely" (Amerine et al., 1965).

The sensory trials were conducted in **triplicate**, and the mean scores obtained for each attribute were subjected to **statistical analysis** using **one-way analysis of variance (ANOVA)** to determine the level of significance among treatments. The differences between means were compared using **Duncan's Multiple Range Test (DMRT)** at a 5% level of significance ($p < 0.05$), as described by **Steel and Torrie (1980)**.

The **highest overall acceptability (7.40 ± 1.17)** was observed at **5% sugar**, followed closely by 7% and 10%.The differences among the sugar levels are **not statistically significant** (as indicated by the same superscript "^{a}" across treatments).**Color & appearance** and **flavor** scores slightly declined as sugar increased, while **taste** and **consistency** remained nearly constant.This suggests that adding more sugar does not significantly enhance sensory quality and may slightly dull visual and flavor attributes.



The 5% sugar level recorded the highest mean scores for all sensory attributes, indicating optimal flavor balance and acceptability. Though numerical differences existed, statistical analysis (ANOVA) showed no significant difference ($p > 0.05$) among treatments. Similar findings were reported by Shukla et al. (2019), who observed highest consumer preference at moderate sweetness levels.

5. Conclusion

The study concludes that 5% sugar concentration with 0.1% carrageenan and 0.05% citric acid provides the most balanced sensory and physicochemical properties in cream churning buttermilk. The optimized formulation offers a desirable taste and consistency suitable for commercial production. Future studies may explore low-calorie or natural sweeteners and assess storage stability.

6.Aknowlegement
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